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Truck Driver Behavior and Travel Time Effectiveness Using Smart GPS

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Abstract

The pattern of coal transportation is very dependent on the behaviour of the driver, which influences the effectiveness of travel time. Good driver behaviour will affect the optimization of travel time, and scenarios need to reduce travel time wastage. This study aims to optimize travel time and sensitivity analysis based on the influence of driver behaviour, truck travel movements and the use of travel time on coal haul roads. The research method uses a field survey with a GPS tracker, a smart GPS server 3.3, google earth and statistics. The results showed that the driver's behaviour greatly influenced the pattern of use of travel time and truck travel speed. Coal transportation in the morning can be more optimal than night so that that travel time wastage can reduced by 40%. The proposed optimization scenarios can save 36.7% - 48.61% of the existing travel time and the transport cycle can be increased to four to five times. So that with the addition of the cycle, it will increase the income of the transport company and the driver's income. With smart GPS, companies can improve the performance of transportation services in company management, get coal supplies on time.

Keywords: Drivers Behaviour, Travel Time Effectiveness, Truck, Coal Roads, Scenarios.

1. Introduction

The Borneo Economic Corridor in MP3EI is a National Energy and Mining Product Production and Processing Center, especially the coal sector. The coal commodity is the primary commodity of South Kalimantan according to the results of the Dynamic Location Quotient > 1 and the need for coal production has increased from the 2011-2016 period of 24 million tons. Coal is the primary fuel for electricity, metallurgy, cement, textile, pulp, fertilizer and briquette factories. Coal transportation distribution is a significant thing in coal availability [1].

There have been many studies to analyze driver behaviours such as street characteristics influence, driver category and car performance on urban driving patterns [2]. Davidovic et al. (2018) estimated the professional driver's fatigue as a modern era problem [3]. Dinges (1995) focused on the sleepy behaviour influence; and accidents that occur, exploration studies about long-distance truck drivers [4, 5]. Zicat et al. (2018) estimated young drivers with cognitive function by analyzing the relationship between attitude, driving, cognition and personality [6]. Moreover, Kirti et al. (2019) got the effects of work-rest patterns, lifestyle and payment incentives drivers on long-haul truck driver sleepiness [7]. Meng et al. (2019) reported on the driving fatigue by surveying the taxi drivers and truck-related to accidents in professional drivers [8].

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Transportation is very dependent on the driver behaviour who provides services in the form of timeliness and safety in driving. Reliable driver behaviour, expertise, discipline, work motivation, and professionals can optimize the travel timeliness for each mining transport activity in order to avoid delays and time-wasting that is a loss for the company. Driving is related to factors in the driver who then determine driving behaviour and related to on-going social situations. Bad driver behaviour can affect the use of travel time such as the duration of the rest is too long, the stopping frequency at the food stall or the side road, staying up so that it results in drowsiness and fatigue, thereby reducing the alertness level, unstable speed and working in uncomfortable conditions. The driver behaviour is concerned with dynamic driving characteristics such as road safety, fuel efficiency or good driving patterns.

Modelling and recognizing human driving behaviour has attracted researchers from various scientific disciplines such as physiology, psychology and behaviour for more than fifty years. Significant advances have made from various individual studies on various aspects of human behaviour. The driver model research has made based on the perspective of human factors and vehicle dynamics [9].

Driver behaviour determines vehicle actions in traffic. Research on driver behaviour and vehicle speed approached speed with driver characteristics, traffic conditions and vehicle type with comparing suburban areas and urban [10]. Familar et al. (2011) analyzed speeding behaviour with a multilevel modelling approach [11]; Gehlert et al. (2012) introduced an evaluation of the different types of dynamic speed display signs [12]. Besides that, Eboli et al. (2017) investigated car users' driving behaviour through speed analysis, and Galkin et al. (2018) produced modelling trucks that speed on the route considering the driver's state [13, 14]. Likewise, research on travel time from various perspectives such as that conducted by Rahmani et al. (2015) with a non-parametric research for estimation of route travel time distributions [15]. Moghaddam et al. (2017) analyzed the effect of travel time information, reliability, and level of service on driver behaviour using a driving simulator [16]. Uchida (2014) has estimated the travel time value and travel time reliability in road networks [17].

Many methods and models are carried out to optimize travel time, such as the TRIP model for predicting travel time on the Seattle metropolitan area network road, based on large volumes of GPS data [18]. Jenelius (2012) has examined the travel time value variability with flexible scheduling, trip chains and correlated travel times [19]. Westgate et al. (2013) analyzed several approaches exist to predict the probability distribution of travel time on the road network model exclusively link-level variability and assume the independence of travel time on the route [20]. Similar research also conducted by Hunter et al. (2013) with estimates of large-scale cyber-physical systems using streaming data for predicting travel time variability using GPS [21].

This study aims to present an analysis of driver behaviour from the perspective of driving data in detail, such as speed and travel time usage. It is well is known that driving a truck is a complex and dynamic task that requires the driver has driving skills. Modelling of driving behaviour and recognition driver characteristics are needed to ease the driver's workload and improve reliability. This study uses a GPS tracker that connected to a smart GPS server 3.3. Implementation of GPS tracking on trucks has been shown to improve driver behaviour, driver safety, reduce unnecessary time, control fuel, and truck operational costs others. Also, increase vehicle utilization effectively, increase productivity and customer service, also can manage vehicles more effectively and control fleet costs. Operating a fleet is not only about managing vehicles but also requires the management of the people who drive it. That is where the wireless fleet management system (GPS tracker/smart GPS) can provide many benefits for the coal company and its drivers. Using GPS data can positively train and reward drivers for adopting safer and more efficient driving habits. Drivers get essential information, accurate, get roadside assistance (emerging situation), work verification is done on time and existing data that affects many other aspects of driver works. The smart GPS installation in coal trucks can help operators and field supervisors to track trucks, give warnings, monitoring truck locations, provide information, and mark the speed of each truck. Even the field supervisor will call the driver who stops too long somewhere and knows the location if there is damage to the truck so that it is easy and quick to help. In general, smart GPS installed to avoid truck loss and a waste of travel time, so that the use of fuel can also reduce.

2. Research Methodology

2.1. Location of Study

The research was carried out on a private hauling coal road in South Kalimantan Province with an aggregate base course road structure. The distances of the hauling coal route are 56.1 kilometres between the stockpile to Sungai Puting Port, and the road slope is a maximum of 20.3 %, -15.5 %. This research was conducted in the period from September 2018 - March 2019. The location of the study can be explained in Figure 1.

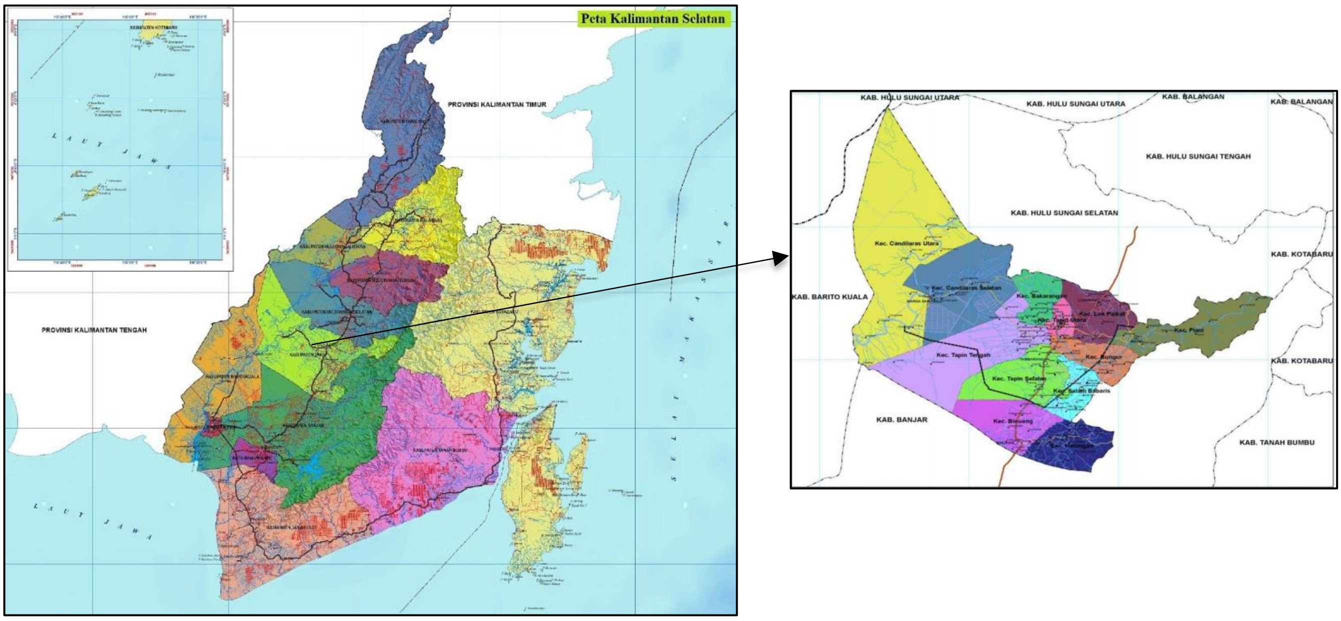


Figure 1. The research location on the particular coal road, Rantau District, South Kalimantan, Indonesia

2.2. Participants and Measurement

The discussion in the study divided into two topics, namely (1) the coal truck behaviour with 116 drivers working at the coal transportation company PT. BEM in the Rantau District, South Kalimantan Indonesia and (2) the travel time usage of truck movement. For estimated driver behaviour used driver characteristic questionnaires namely (a) driver characteristics including age, education, population status, income/month, truck driver experience, several mobile phones, cellphone usage while driving, workdays/month, driving frequency, stops frequency, driving duration/day, place to stop, activities at rest, total sleep time/day, activity in social media and cigarette consumption/day. The usage of coal truck travel time using a GPS tracker connected to smart GPS server 3.3 software installed on three Hino 500 FM 260 Ti trucks with codes A, B, and C in a one-month observation. The flowchart of this research method is available in Figure 2.

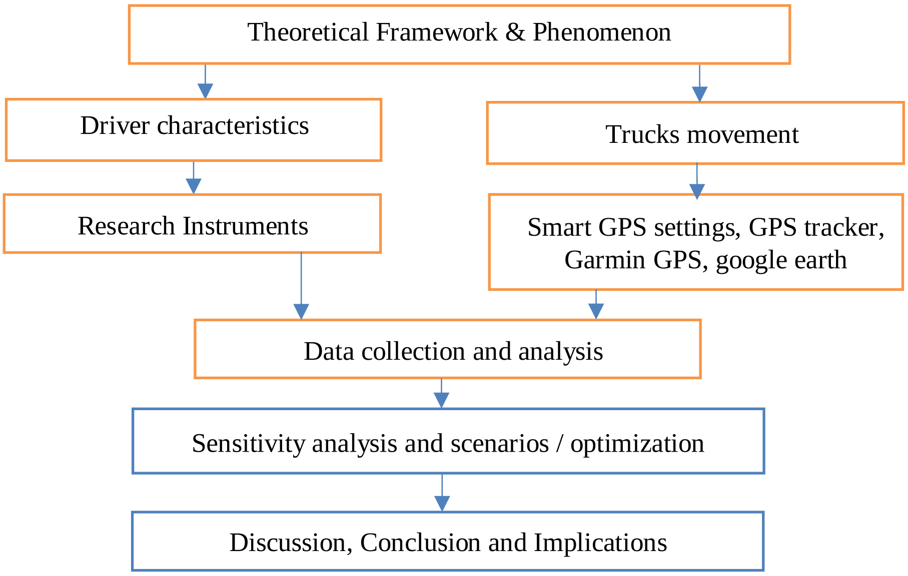


Figure 2. Research flowchart methodology

The driver demographics characteristics data were analyzed using SPSS version 24 software. The characteristics of data were analyzed using descriptive statistics to investigate the demographic characteristics of the participants. The travel time usage of coal trucks using a smart GPS server 3.3 connected with a GPS tracker will get a route, the truck movement, coordinates of movement and stops, truck speed, and stop location. Smart GPS results will be moved to Google earth so that they display the level of the road, geometric, and height of the road crossing. Collected data are analyzed and compared accordingly. Then sensitivity analysis and optimization scenarios are performed based on the driver's behaviour patterns and truck movements, so that travel time is more reliable.

3. Results and Discussion

3.1. Characteristics and Behaviour of Coal Driver

The driver's characteristic is done to find out the driver's profile so that it will facilitate an understanding of the behaviour of the travel time usage. Characteristics fields were distributed to 116 coal truck drivers. The results of driver characteristics can be seen in Table 1.

Table 1. Driver demographic characteristics

Variable	N	%	Variable	N	%
Age			Driving frequency/day		
≤ 25 years	9	8	≤ Three times	36	31
26-35 years	59	51	Four times	67	58
36-45 years	33	28	Five times	11	9
≥ 45 years	15	13	> Five times	2	2
Education			Stop frequency		
≤ junior high school	5	4	Never	17	15
Senior High School	96	83	1-2 times	29	25
3-year diploma	12	10	>Two times	70	60
≥ bachelor	3	3			
Population status			Driving duration/day		
Local residents	81	70	Normal, <8 hours	38	33
Outside residents	35	30	Weight, > 8 hours	78	67
Income/month			Place to stop		
≤ 3 million	28	24	Food stalls	77	67
3-6 million	67	58	The side of the road	34	29
≥ 7 million	21	18	Workshop/home	5	4
Truck driver experience			Activity at rest		
≤ One year	13	11	Sleep	32	28
2-4 years	95	82	Eat	57	49
5-7 years	5	4	Relax/social media	4	3
≥ Eight years	3	3	Others	23	20
Number of cellphones			Total sleep time/day		
One	78	67	Less (<seven hours)	39	66
Two	33	29	Enough (> seven hours)	77	34
> two	5	4			
Use of HP/day			Active in social media		
One time	15	13	Active	15	13
2-3 times	35	57	Middle class	67	58
> 3 times	66	30	Not active	34	29
Working day/month			Consumption of cigarettes/day		
≤ four days	65	56	Do not smoke	5	4
5-7 days	35	30	1-6 sticks	24	21
≥ eight days	16	14	7 - 12 sticks	87	75

Table 1 shows that the highest education qualification, according to recruitment, is a senior high school (83%). The most significant population status of residents is 70%, this aims to empower people local/native, without providing housing and understanding the field situation to reduce conflict during coal-hauling work. The highest income in the range of 3-6 million (58%) and the driving frequency highest/day is four cycles (58 %). It means that the driver will get 3-6 million/month if the more four times frequency/day. The average income/month is 4.6 million is higher than the Regional Minimum Wage (UMR) of South Kalimantan Province (2.7 million). Data in the field shows that the driver's income depends on the driving frequency/day. The revenues of 4.6 million/month based on the driving frequency/day at an average of 4 cycles (calculated from filling in the stockpile to the port and returning to the stockpile). The highest driving experience is in the range of 2-4 years, and the driving duration/day is relatively heavy, namely > 8 hours/day (67%).

The frequency of stopping during the trip is high, which is more than two times (60%) with stops in food stalls (67%), roadside (29%) and workshops/houses (4%). Drivers use the time to stop for breaks, including sleeping, eating, relaxing, social media and others. Most rest periods used for eating and sleeping. Driver behaviour can also be seen from the usage of the total sleep time. From the data produced, the driver has less sleep time (66%) so that it can increase driver fatigue. The work/month holiday that the driver gets is an average of four working days. The driver himself determines the working day because the employment status is freelance.

The use of travel time/day is also influenced by ownership and the use of mobile phones, especially for communication. The average driver has only one mobile phone with the frequency of receiving/making calls 2-3 times and classified as active in social media. In general, someone active in social media will use free time to check or play social media. Most drivers consume cigarettes with a large amount of 7-12 cigarettes (75%), but the procedure during driving is forbidden to smoke to avoid combustible coal fires so that drivers consume cigarettes only outside driving hours.

3.2. The Travel Time Usage

In the map, the results of smart GPS server 3.3 also display stops along the route. If the image zoomed in such a way, it would display lines or trail lines of truck trips that are not the same even though in the same route. The results of the coal trucks on three trucks with numbers BH 5000 (A), 5001 (B) and 5004 (C), which include special lanes along with coordinates, the average speed data, the maximum speed data, and where stops can see as follows Figure 2.

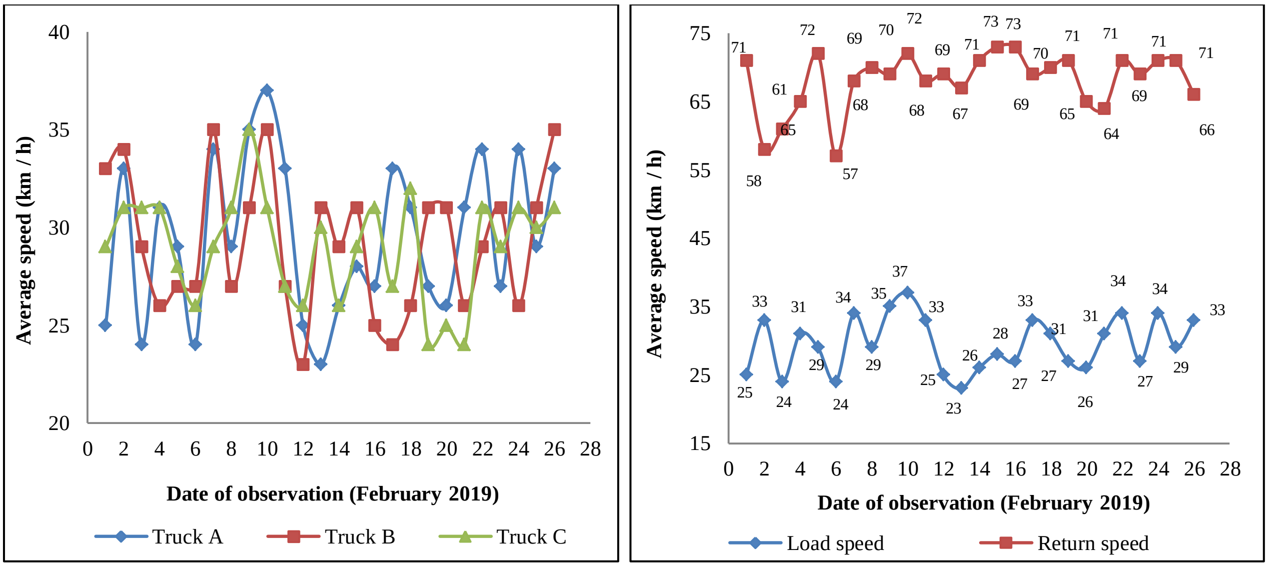


Figure 3. The average speed of coal transport within 28 days of observation (a) trucks A, B, and C with on-loading travel speed (b) trucks with on-loading travel speed and off-loading travel speed

On-loading travel time is travel time, which spends from the stockpile to the port with coal load, and off-loading travel time is the travel time from the port to the stockpile without coal load. In Figure 3(a) shows that the variation in the trucks average speed (trucks A, B and C) in one month of non-stop observation (GPS tracker is not turned off in one month) both during motion/travel time and time temporarily stopped (food stalls, roadside and workshops), but also the time to stop after doing 2 - 4 times the transport cycle. The speed of the truck is different every day. The average speed total in one month of observation is 30 km /hour. The highest average travel speed occurred on February 11, 2019, at 37 km/hour but still below the speed limit of 40 km/hour when on-loading travel.

The minimum average speed occurs on February 14, 2019, at 23 km/hour. In Figure 3(b) shows that the average speed comparison with the condition of on-loading travel speed and the off-loading travel speed with three trucks every day in one month. The maximum speed is 71 km/hour, and the minimum speed is 23 km/hour. The output of the average truck speed is the smart GPS server 3.3 results originating from a GPS tracker installed in each truck. Declining travel speeds can indicate on bends, inclines, and descent, road surface damage, road constriction, and rainy weather.

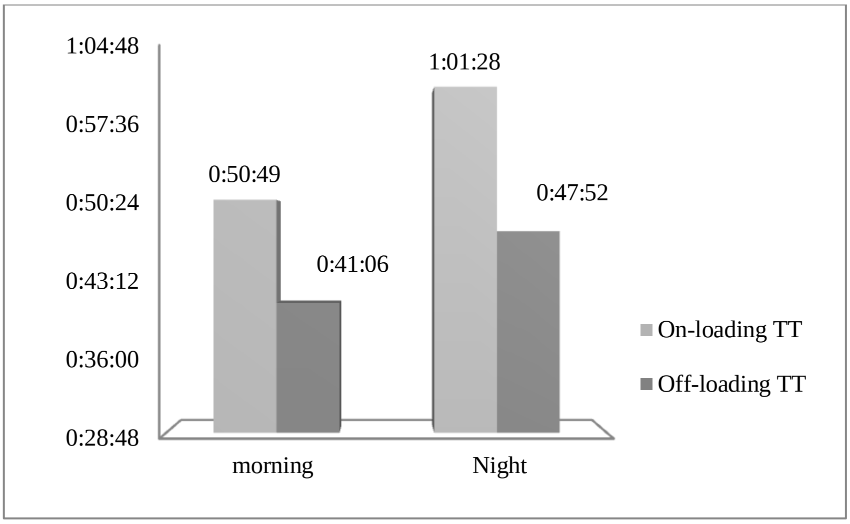


Figure 4. Comparison of travel time usage between on-loading travel time and off-loading travel time within one-month observations

Figure 4 shows a result comparison of the travel time usage between on-loading travel time and off-loading travel time during the morning afternoon and night conditions. At the time of the morning, it gets the on-loading travel time of 0:50.4, whereas, at night, it is 1:01:28. The value of the off-loading travel time in the morning/afternoon is 0:41:06 and night to 0:47:52. From the results of the travel time usage that was recorded from a smart GPS server 3.3 for one month, it was found that average travel time at night trip is longer than the morning-afternoon trip. It can indicate that there is a decrease in the driver's condition, a decrease in the level of alertness, increased fatigue and lack of street lighting at night. Extended workload and work duration will cause fatigue to the driver with a marked decrease in the safety level and the driver's health condition.

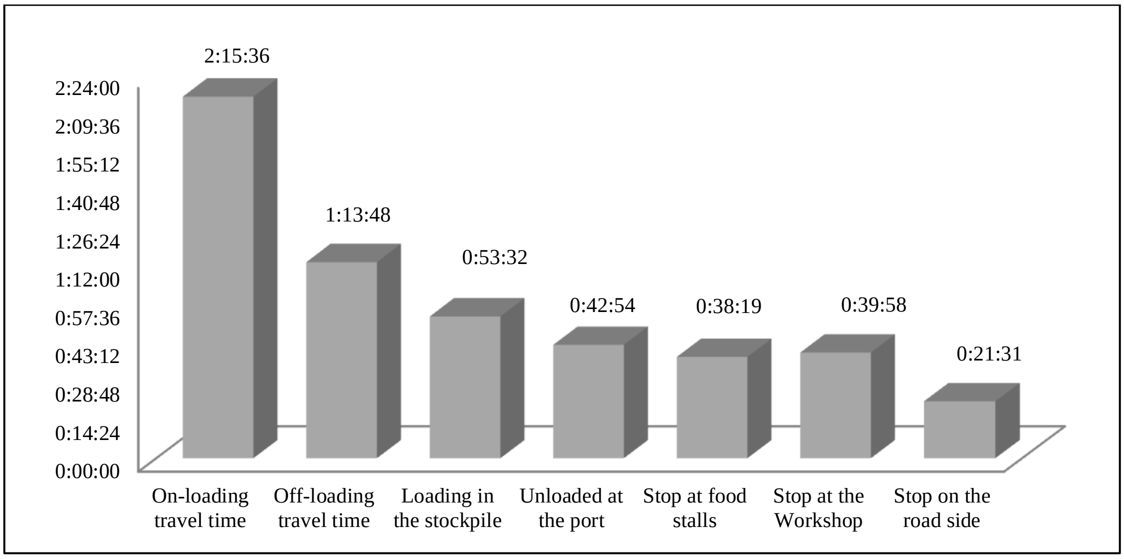
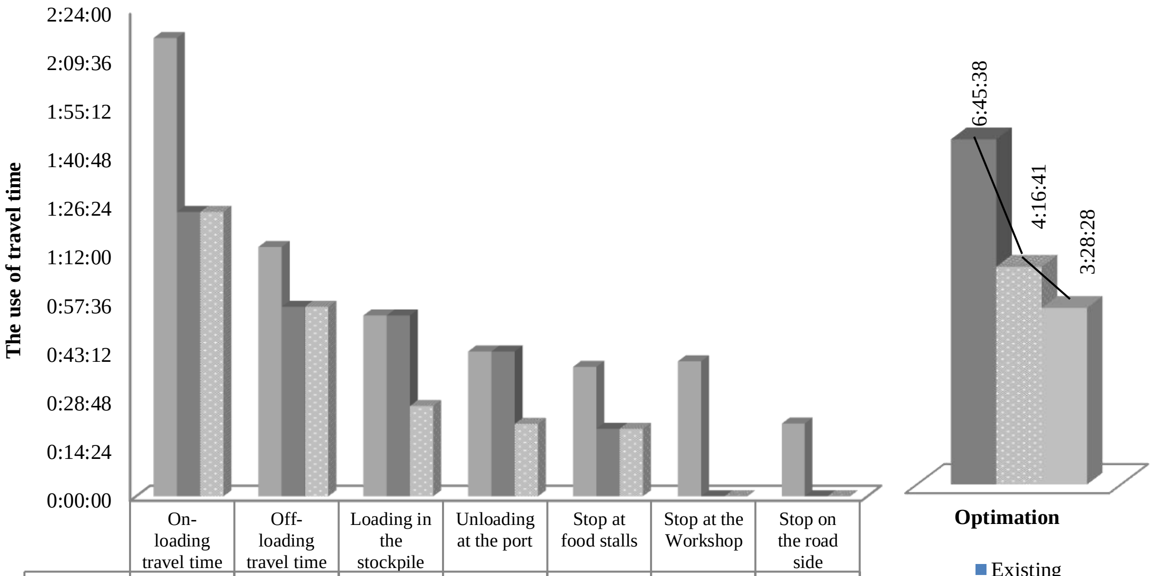


Figure 5. The average travel time usage at coal private haul roads in one travel cycle time

Figure 5 shows that the average duration of travel time usage for one travel cycle time, namely travel time between the stockpile to the port and returning to the stockpile again. The travel time usage consists of the trucks travel time duration with on-loading travel time is 33.4% (2 h 15 m 362 s) and off-loading travel time at 18.2% (1 h 13 m 48 s). The duration usage of the coal loads in the stockpile to the port with a route distance of 56.1 km and normal on-loading travel speed on roads specifically for coal transportation 40 km/hour, then the standard duration is 1 h 24 m 9 s, while the standard duration of off-loading travel speed 60 km/hour is 56 m 6s. From this data, there is a waste of travel time, namely on-loading travel time with 57 minutes and return time of 51 m 27 s. The waste of travel time usage on coal haul road indicated rainy weather, rough road conditions, dusty roads, drowsy, tired driver behaviour, reduced alertness, long periods of rest, and stopping and obstacles to vehicle conditions.

The use of travel time duration when coal loading in the stockpile is 13.2% (53 m 32 s) and at the coal unloading time at the port is 10.6% (42 m 54 s), and it can be reduced by proper port management, arrangements for entering/exiting ports, reducing queuing time, increasing conveyor belts and repairing port roads. Whereas the duration of use in the food stall is 9.4% (38 m 19 s) and on the roadside, 5.3% (21 m 31 s) can be reduced by providing regular meals for drivers, provision of drinking water to trucks, counselling on staffing procedures and transportation of coal. Long stops can damage the condition of vehicles and roads, especially in trucks with coal loads, because, in general, the load ranges from 28 - 30 tons (exceeding the load). The duration of time spent in the workshop of 9.9% (39 m 58 s) indicated that because of vehicle damage, vehicle checking, refuelling, and transportation management. So that if the cause can resolve, then the travel time will be more optimal and profitable.



	On-loading travel time	Off-loading travel time	Loading in the stockpile	Unloading at the port	Stop at food stalls	Stop at the Workshop	Stop on the road side
Existing	2:15:36	1:13:48	0:53:32	0:42:54	0:38:19	0:39:58	0:21:31
Scenario 1	1:24:09	0:56:06	0:53:32	0:42:54	0:20:00	0:00:00	0:00:00
Scenario 2	1:24:09	0:56:06	0:26:46	0:21:27	0:20:00	0:00:00	0:00:00

Figure 6. Sensitivity scenario using average travel time in one travel cycle

Figure 6 shows three comparisons of situations, namely the existing situation, scenario 1 and scenario 2. The optimation sensitivity includes two scenarios, namely:

(1) *Scenario 1* was changed the coal trucks travel speed with on-loading travel using a planned speed of 40 km/hour and off-loading travel speeds of 60 km/hour, the duration of loading time in stockpiles and unloading at ports fixed because the mining system has three different authorities, namely the owner of the mine, road owners of transport and port owners. In the scenario, one only changes the travel time associated with the transport road only. For a stop at the food stalls, it is used one hour to rest. Because, on average, one day is three cycles, then one hour is divided into three cycles, which is twenty minutes. To stop at the workshop and on the roadside is eliminated. The results obtained were a reduction in waste of travel time by 48.61%.

(2) *Scenario 2* was changed travel time on the coal hauling, loading in the stockpile and unloading at the port. The trucks speed with on-loading travel speed using 40 km/hour and off-loading travel speed 60 km/hour. The use of travel time in the stockpile and port is changed in half from the existing conditions by the entrance management to reduce the queue, add the conveyor belt, repair the port road and enlarge the entrance/exit. The stop was fixed for twenty minutes and stopped at the food stalls, and the roadside eliminated. So the results that can be optimized are 36.72%.

With the results of scenario 1 and 2, the transport cycle can be increased to four to five times. So that with the addition of the cycle, it will increase the income of the transport company, the driver's income and the availability of coal stock is guaranteed. Trucks are coal-hauling units that provide relatively low hauling costs and flexible because of their high travel speeds. The high travel speeds allow for quicker hauling of coals when travelling on established roads.

4. Conclusion and Research Implications

The use of smart GPS in each truck is significant to improve and control the pattern of coal driver behaviour. Driver characteristic data can illustrate driver behaviour that affects travel time performance. The high income and driving experience affect the work motivation of drivers. The frequency of stopping during the trip, time to stop for breaks, the less sleep time, driver fatigue, and duration of mobile phone / social media usage significantly affect travel time. From the results of the characteristics of the driver can be compared with the survey results of truck movements as primary data so that there is a match between the characteristics of the driver's data and the movement of the truck, which results in inefficient travel time. Sensitivity analysis and optimization are implemented by reducing stop times during trips, queuing at stockpiles and ports, changing sleep and rest patterns and adjusting workloads to reduce driver fatigue.

Optimizing travel time can be done with several scenarios requiring cooperation between drivers, transport owners, road entrepreneurs, mining owners, and ports. The transportation of coal in the morning can be more optimum than a night and can reduce by 40% of the current travel time. Even though the scope of hauling coal is local and uses local drivers, standardization of transport must be applied towards more enormous profits. By changing driver behaviour in the use of time, travel time reliability can be achieved. The next research that can be done to analyze the coal transportation system policy covering drivers, vehicle and road conditions. Also, research on the effects of topography and the quality of road can be analyzed so that all aspects related to the transportation of coal can be analyzed. The South Borneo because of the geographical and geological conditions of the area.

5. Funding

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6. Conflicts of Interest

The authors declare no conflict of interest.

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